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DECODER DEVICE FOR DECODING PACKET SIGNALS COMPOSED OF  
CONTROL CODES AND DATA CODES

CROSS-REFERENCE TO RELATED APPLICATION

5 This application is based upon and claims benefit of  
priority of Japanese Patent Application No. 2000-158442 filed  
on May 29, 2000, the content of which is incorporated herein  
by reference.

10 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a decoder device  
for use in a receiver for decoding packet signals that  
include data codes and control codes.

15 2. Description of Related Art

The IEEE-802.11a standard requires that a header of  
a packet signal should include control codes containing  
information for decoding the packet signal. The decoding  
information consists of a modulation formula (QPSK, BPSK, 16-  
20 QAM or 64-QAM) and a coding rate (1/2 or 3/4) of an error  
correction code. The packet signals received by a receiver  
are divided into data codes and control codes, and the  
control codes are first decoded and analyzed to determine  
which one of the modulation formulae and which one of the  
25 coding rates are specified in the control codes as the  
decoding information. Since it is predetermined that the  
control codes themselves are coded under the modulation

formula BPSK and the coding rate  $1/2$ , the control codes can be decoded based on the BPSK and the coding rate  $1/2$ . After the decoding information is detected, the data codes are decoded based on the detected decoding information.

5        The decoding is performed using a Viterbi decoder.  
Since the decoding process performed by the Viterbi decoder is relatively slow, it takes a long time to process the packet signal as a whole, if the data codes are decoded based on the decoding information after it is obtained by decoding and analyzing the control codes. A real time decoding is not possible.

#### SUMMARY OF THE INVENTION

15        The present invention has been made in view of the above-mentioned problem, and an object of the present invention is to provide an improved decoder device in which the time required for decoding is shortened, thereby realizing real time processing.

20        Packet signals that include control codes and data codes structured in an orthogonal frequency division multiplexing (OFDM) format are received by a receiver such as a mobile receiver and decoded in a decoder device of the receiver. The control codes include a decoding formula consisting of a modulation formula and a coding rate as  
25        information for decoding the data codes. The decoder device is composed of a divider such as a decomposite circuit, plural decoders and an output selector.

The divider divides out the control code and the data code included in the packet signal and feeds those codes to the decoders. One of the decoders decodes the control code, and the decoded control code is analyzed to obtain the decoding formula contained in the control code. During a period in which the decoded control code is being analyzed, the data code is decoded in the plural decoders based on respective decoding formulae which are preset in the respective decoders. A decoding formula preset in one of the decoders coincides with the decoding formula included in the control code.

The decoding formula obtained from the control code and all the data signals decoded in the respective decoders are fed to the output selector. The output selector selects a data signal, from among the plural data signals, that is decoded based on a decoding formula which coincides with the decoding formula obtained from the control code. Each decoder is composed of a modulator, a de-interleaver and a Viterbi decoder. The decoder device, however, may be structured to use those components commonly in the plural decoders.

Since the data code is decoded in the period during which the control code is being analyzed, the time required for decoding the packet signal is shortened, and thereby a real time processing is realized.

Other objects and features of the present invention will become more readily apparent from a better understanding

of the preferred embodiments described below with reference to the following drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing a structure of a decoder device as a first embodiment of the present invention;

FIG. 2 is a timing chart showing operation of the decoder device shown in FIG. 1; and

FIG. 3 is a block diagram showing a structure of a decoder device as a second embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will be described with reference to FIG. 1. The decoding device shown in FIG. 1 is a decoding device used in a receiver which receives packet signals using the orthogonal frequency division multiplexing (OFDM) format for MMAC. A base band signal, the amplitude and phase of which are adjusted is fed into the decoder device as a packet signal through an antenna, a receiving circuit, a fast Fourier transform (FFT) processor, an equalizer and so on (those components are not shown in FIG. 1). The packet signal is composed of control codes and data codes which are fed to the decoder device in this order.

The packet signal is distributed to decoders 21-26 (six decoders, decoder-A, decoder-B, decoder-C, decoder-D,

decoder-E and decoder-F are used in this particular embodiment) through a distributor (a decomposite circuit) 10.

The decoder-A 21 is used for decoding both of the control

codes and the data codes, and other decoders 22-26 are used

for decoding the data codes. The distributor 10 divides out

the control codes from the packet signal and feeds the

control codes to the decoder-A 21. Then, the data codes are

fed to all the decoders 21-26.

As shown in FIG. 1, each decoder 21-26 is composed

of a demodulator 20a, a de-interleaver 20b and a Viterbi

decoder 20c. The demodulator 20a and the de-interleaver 20b

process the codes fed thereto under either one of the

modulation formulae, QPSK, BPSK or 16-QAM. The Viterbi

decoder 20c decodes the codes under one of the coding rates,

1/2 or 3/4. More particularly, the decoder-A 21 is set to

decode under the modulation formula BPSK and the coding rate

1/2; the decoder-B 22 under BPSK and 3/4; the decoder-C 23

under QPSK and 1/2; the decoder-D 24 under QPSK and 3/4; the

decoder-E 25 under 16-QAM and 1/2; and the decoder-F 26 under

16-QAM and 3/4. The demodulators 20a, de-interleavers 20b

and Viterbi decoders 20c in the respective decoders 21-26 are

structured to operate in the above manner.

The control codes are first decoded by the decoder-A

21, and then, the data codes are decoded by the decoders 21-

26. All the signals decoded by the respective decoders 21-26

are fed to an output selector 30b in a receiver controller 30.

The signals decoded by the decoder-A 21 is further fed to a

control code analyzer 30a in the receiver controller 30. The control code analyzer 30a analyzes the decoded control codes fed thereto and determines the modulation formula and the coding rate contained in the control codes as information for decoding the data codes. The output selector 30b selects a decoded data signal, from among decoded data signals fed from the respective decoders 21-26, which is decoded based on the decoding information (the modulation formula and the coding rate) determined by the control code analyzer 30a. The selected decoded data signal is outputted from the output selector 30b as a decoded packet signal.

Referring to FIG. 2, timing of the process performed in the decoder device will be explained. The control codes and the data codes included in the packet signal are fed to the decoder device in this order. First, the control codes are decoded by the decoder-A 21, and the decoded control codes are outputted. Then, the data signal outputs A-F decoded by respective decoders 21-26 are outputted. Since a period of time required to decode the data codes in the respective decoders 21-26 is not all the same, the output timing of the decoded data is somewhat different from one another. However, the decoder device is structured so that the fastest decoded data output appears after the decoded control code is outputted. The decoded control code is analyzed to determine the decoding information contained therein, while the data codes are being decoded.

A decoded data output that is decoded based on a modulation formula and a coding rate, both coinciding with those obtained by analyzing the decoded control codes, is selected from among the decoded data outputs A-F and outputted from the output selector 30b. FIG. 2 shows an exemplary situation where the decoded data output C is selected. As explained above, the decoding process time is shortened because the data codes are decoded while the decoded control code is analyzed, thereby realizing a real time process of the packet signal fed to the decoder device.

A second embodiment of the present invention will be described with reference to FIG. 3. In the first embodiment described above, the decoders 21-26 are arranged all in parallel. In the second embodiment, components are used commonly to plural decoders. The decoder device as the second embodiment is composed of a distributor (a decomposite circuit) 100, demodulators 201-204, de-interleavers 205-208, an OR-circuit 209, dummy bit inserters 210-212, and decoders 213-218. A frequency shown in parentheses in each decoder 213-218 is a clock frequency under which each decoder operates.

The distributor 100 divides the packet signal fed to the decoder device into the control code and the data code, and feeds the control code to the demodulator 201 and the data code to the demodulators 202-204. Since the packet signal before decoding is a base band signal having the OFDM format, it is possible to cutout the packet signal into 4-bit

signals to feed them to the demodulators 201-204 if the packet signal is a 12-bit signal.

The control code fed to the demodulator 201 is demodulated therein under the BPSK modulation formula and is fed to the de-interleaver 205 which de-interleaves the demodulated signal. The de-interleaved signal is fed to the decoder 213 via the OR-circuit 209 and decoded therein. Thus, the control code decoded under the modulation formula BPSK and the coding rate 1/2 is obtained and fed to the receiver controller 30. The receiver controller 30 analyzes the decoded control code, in the same manner as in the first embodiment, to obtain the modulation formula and the coding rate contained therein as information for decoding the data code.

The data code fed from the distributor 100 to the modulator 202 is demodulated under the 16-QAM modulation formula and is fed to the de-interleaver 206 that de-interleaves under the 16-QAM modulation formula. The de-interleaved signal is fed to the decoder 213 via the OR-circuit 209 and to the decoder 214 via the dummy bit inserter 210 that inserts a dummy bit into the de-interleaved signal. The decoder 213 outputs the data signal decoded under the 16-QAM and the 1/2 coding rate, while the decoder 214 outputs the data signal decoded under the 16-QAM and the 3/4 coding rate.

The data code fed from the distributor 100 to the modulator 203 is demodulated under the QPSK modulation



formula and is fed to the de-interleaver 207 that de-interleaves under the QPSK modulation formula. The de-interleaved signal is fed to the decoder 215 and to the decoder 216 via the dummy bit inserter 211 that inserts a  
5 dummy bit into the de-interleaved signal. The decoder 215 outputs the data signal decoded under the QPSK and the 1/2 coding rate, while the decoder 216 outputs the data signal decoded under the QPSK and the coding rate 3/4.

Similarly, the data code fed from the distributor  
10 100 to the modulator 204 is demodulated under the BPSK modulation formula and is fed to the de-interleaver 208 that de-interleaves under the BPSK modulation formula. The de-interleaved signal is fed to the decoder 217 and to the decoder 218 via the dummy bit inserter 212 that inserts a  
15 dummy bit into the de-interleaved signal. The decoder 217 outputs the data signal decoded under the BPSK and the 1/2 coding rate, while the decoder 218 outputs the data signal decoded under the BPSK and the coding rate 3/4.

Thus, six decoded data signals which are  
20 respectively decoded under six combinations of three modulation formulae (16-QAM, QPSK and BPSK) and two coding rates (1/2 and 3/4) are fed to the receiver controller 30. The receiver controller 30 outputs the data signal which is decoded under the decoding information (consisting of a  
25 modulation formula and a coding rate) which coincides with the decoding information obtained by analyzing the decoded control code. In other words, the receiver controller 30

selects one decoded data signal from among six decoded data signals and outputs the selected data signal as a decoded packet signal.

Since the data codes are decoded during a period in which the control code is analyzed in the same manner as in the first embodiment, the time required for the decoding process as a whole is shortened, and thereby the real time processing is realized.

It is necessary, in both of the foregoing embodiments, to output the decoded data signals after the analysis of the control code is completed. For this purpose, the decoded data signals may be temporality held in a memory such as a buffer until the control code analysis is completed, if such is necessary in a particular arrangement of the decoder device. For example, a buffer 219 (shown in FIG. 3 with a dotted line) may be disposed after the decoder 214. In the conventional decoder device, such buffers are always required to hold the decoded data signals because the decoded data signals are outputted during the analysis of the control code. However, in the present invention, the number of the buffers can be reduced if such buffers are necessary due to a particular structure of the decoder device.

In the second embodiment shown in FIG. 3, a pair of decoders corresponding to each modulation formula is used to obtain two decoded signals decoded under two coding rates,  $1/2$  and  $3/4$ . To simplify the device, it is possible to use a single decoder corresponding to each modulation formula and

to determine whether the de-interleaved signal goes through the dummy bit inserter or not according to coding rates instructed from the receiver controller 30. In this arrangement, buffers for storing the outputs from the de-interleavers until the data code analysis in the receiver controller 30 is completed are required, and accordingly the decoding process is not carried out in real time. However, because the process up to the de-interleavers can be carried out during the control code is being analyzed, the processing time as a whole is shortened compared with that in the conventional device.

The number of combinations of the modulation formulae and the coding rates is not limited to six, but it may be changed to other numbers according to communication systems. Further, the receiver is not limited to a mobile station, but it may be other stations such as a base terminal.

While the present invention has been shown and described with reference to the foregoing preferred embodiment, it will be apparent to those skilled in the art that changes in form and detail may be made therein without departing from the scope of the invention as defined in the appended claims.